

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants: TETSUKA et al

Serial No.: 10/784,275

Filed: February 24, 2004

For: Plasma Processing Apparatus And Plasma Processing Method

Art Unit: 1792

Examiner: R. Zervigon

Conf. No.: 8920

APPEAL BRIEF

Mail Stop: Appeal - Patent (Fee)
Commissioner For Patents
P.O. Box 1450
Alexandria, VA 22313-1450

March 18, 2008

Sir:

This appeal brief is being filed under 37 CFR 41.37 in connection with the appeal of the above-identified application, a notice of appeal having been filed on January 18, 2008.

Real Party In Interest

The real party in interest is Hitachi, Ltd. of Japan and Hitachi High-Technologies Corporation of Japan.

Related Appeals and Interferences

On information and belief, no other appeals or interferences are pending.

Status Of Claims

Claims 1, 2, 4, 5 and 7 - 14 are pending in this application, claims 3 and 6 having been cancelled, and claim 9 standing withdrawn from consideration as being directed to a non-elected invention. A copy of claims 1, 2, 4, 5, 7, 8 and 10 - 14, which are on appeal, appear in the Claims Appendix.

Status of Amendments

No Amendment was filed in response to the final office action dated October 18, 2007.

Summary of the Claimed Subject Matter

The present invention relates to a plasma processing apparatus which reduces damage to inner walls of the reaction chamber caused by application of high frequencies to a substrate to be processed, and which enables stable processing to be performed for a long time.

Independent claim 1, and therewith dependent claims 2, 4, 5, 7, 8 and 10 - 14, on appeal, relate to a plasma processing apparatus, as illustrated in Fig. 1 wherein a reaction chamber container 10 defines a reaction chamber 1, in which a plasma 9 is generated by applying a high frequency to a plasma generating high-frequency electrode 17 from a plasma-generating high-frequency power supply 18 for generating the plasma inside the reaction chamber, as described in the paragraph bridging pages 14 and 15 of the specification. The plasma is utilized for processing a substrate in the form of a wafer 4, as illustrated in Fig. 1, which is placed on a wafer holding electrode 14, and which has a second high-frequency applied to the wafer holding electrode 14 from a wafer biasing high-frequency power supply 19, as

described in the paragraph bridging pages 14 and 15 of the specification. As described at page 15, lines 10 - 12 and lines 21 - 25, and as recited in claim 1, a dielectric 102, in the form of insulating material 102, coats or covers a surface portion of an inner wall 101 of the reaction chamber container 10 and is exposed to the plasma in the reaction chamber. Furthermore, as described at page 15, lines 8 - 10, an electrically conductive member 21, (21a as illustrated in Fig. 1, or 21d as illustrated in Fig. 2), is disposed within the reaction chamber so as to be exposed to the plasma within the reaction chamber at a position with respect to the inner wall of the reaction chamber which is covered with the dielectric 102, and the electrically conductive member 21 is electrically coupled to earth one of directly and through the inner wall of the reaction chamber so as to form a DC earth, as illustrated in Figs. 1 and 2, and which enables direct current to flow therein from the plasma, as described at page 19, lines 12 - 18, for example. As recited in claim 1, the electrically conductive member 21 has an area in a range of 0.1% to 10% of the inner wall area of the reaction chamber, noting that page 23, line 24 to page 24, line 4 describes the feature that the conductive material has an area of less than approximately 10% of a whole reaction chamber wall area to function as the effective earth for high frequency to obtain advantageous results without fail, and has at least an area corresponding to 0.1% of the whole reaction chamber wall area. As shown in Fig. 1, and as recited in claim 1, a magnetic field generation means in the form of a field coil 15, as described in the paragraph bridging pages 14 and 15 of the specification, is disposed outside of the reaction chamber so as to apply a magnetic field to the plasma. As recited in claim 1, and as described in the paragraph bridging pages 10 and 11 of the specification, the electrically conductive member forming the DC earth is disposed at a position crossing a magnetic line of force that is closer to

the substrate holder than a magnetic line of force that crosses the inner wall of the reaction chamber having the dielectric therein, noting that as illustrated in Fig. 2 and described at page 18, lines 3-26 of the specification, the variation of plasma density is small along the magnetic lines of force 50 generated by the field coil 15, and the variation of is great in the direction transverse to the magnetic lines of force. The potential distribution, in the plasma corresponds to the density distribution and the conductive members are disposed in the areas where the plasma density and plasma potential are higher compared to those at the sidewall of the inner wall of the reaction chamber.

The dependent claims recite further features of the present invention, wherein dependent claim 2 recites the feature that the dielectric covers 90% or more of a total surface area of the inner wall of the reaction chamber, as described at page 10, lines 3 and 4 of the specification.

Dependent claim 4, which depends from claims 1 or 2, recites the feature that the electrically conductive member forming the DC earth is located at a position within the reaction chamber where a floating potential of plasma is substantially equal to or greater than a floating potential of the plasma at the inner wall of the reaction chamber covered with the dielectric with respect to the high frequency or the second high frequency, as described in the paragraph bridging pages 18 and 19 of the specification.

Dependent claim 5, which depends from claim 1 or 2, recites the feature that the dielectric is a protective coating formed of insulating ceramic such as carbide, oxide or nitride, as exemplified by SiC, boron carbide and alumite, and a thickness d of the dielectric coating is determined so that, with respect to the relationship between frequency f of the high frequency applied to the substrate and the dielectric

constant ϵ of the dielectric, and impedance per unit area $R = d/(2\pi f\epsilon)$ when high frequency is propagated by capacitive coupling through the dielectric is 100 Ω or smaller, as described in the paragraph bridging pages 21 and 22 of the specification.

Dependent claim 7, which depends from claim 1 or 2, recites the feature that either a base material of the electrically conductive member forming the DC earth or a protective coating disposed on a surface of the electrically conductive member forming the DC earth and coming into contact with the plasma is composed of a conductive ceramic SiC, Al or Al compound, as described in connection with Fig. 5 and pages 24 - 26 of the specification, with the conductive ceramic, SiC, Al and Al compound being specifically described at page 26, lines 6 - 8 of the specification.

Dependent claim 8, which depends from claim 1 or 2, recites the feature that a base material of the electrically conductive member forming the DC earth is composed of a non-metallic material such as a conductive ceramic, SiC, Al or Al compound, a conductive part having a conductivity σ of 1 Ω cm or less being provided on a surface of the base material by evaporation, spraying, or interposing, thereby reducing an earth resistance of the electrically conductive member forming the DC earth, as described in the first full paragraph at page 26 of the specification.

Dependent claim 10, which depends from claim 4, recites the same features of claim 5, as described above, which features are described in the paragraph bridging pages 21 and 22 of the specification.

Dependent claim 11, which depends from claim 4, recites the same features as dependent claim 7 as described above, which features are described at pages 24 - 26 of the specification.

Dependent claim 12, which depends from claim 4, recites features corresponding to dependent claim 8, as described above, which features are described in the first full paragraph at page 26 of the specification.

Dependent claim 13, which depends from claim 1, recites the feature that the electrically conductive member is disposed within the reaction chamber and is electrically coupled to earth by a wire extending through the inner wall of the reaction chamber, as clearly illustrated in Fig. 2 of the drawings of this application and described at page 19, lines 16 - 18 of the specification.

Dependent claim 14, which depends from claim 1, recites the feature that the electrically conductive member is positioned in the reaction chamber so as to enable suppression of chipping of the surface portion of the inner wall of the reaction chamber, as described with respect to Fig. 3 of the drawings of this application at page 21, lines 21 - 24 of the specification.

Grounds of Rejection To Be Reviewed On Appeal

Claims 1, 2, 4, 5, 7, 8, 10 - 14 stand rejected under 35 USC 103(a) as being unpatentable over Kadomura; Shingo et al (US 639437B1), referred hereinafter as Kadomura et al, in view of Kawasaki; Yoshinao et al (US 4795529A), referred to hereinafter as Kawasaki et al.

Arguments

In applying Kadomura et al to the claims of this application, the Examiner characterizes the disclosure of Kadomura et al with respect to features of the claims that Kadomura et al teaches as indicated in paragraph 3 at page 2 of the final office action dated October 18, 2007 that "a dielectric (116); Fig. 22b; column 41; lines

7-14) that is exposed to the plasma substantially covers a surface portion of an inner wall of the reaction chamber (21a; Fig. 16, 22b; claim 1)” and that as indicated in the following paragraph i at the top of page 3 of the office action that “the dielectric (112; Fig. 22b-“cordierite ceramics...Al₂O₃+SiO₂”; column 39; lines 33-40) covers 90% or more (see 21a; Fig. 16) of a total surface area of the inner wall of the reaction chamber 21a; Fig. 16, 22b - Claim 2).” Assuming arguendo that Kadomura et al provides the aforementioned features, the Examiner specifically admits in paragraphs i - xii at pages 3 - 8 of the final office action the recited features of the claims which Kadomura does not teach. Looking only to the recited features of claim 1, the only independent claim on appeal, the Examiner admits that “Kadomura does not teach:” (emphasis added).

i. an electrically conductive member is disposed within the reaction chamber ... so as to be exposed to the plasma within the reaction chamber ... at a position with respect to the inner wall of the reaction chamber ... which is covered with the dielectric ..., and the electrically conductive member is electrically coupled to earth one of directly and through the inner wall of the reaction chamber ... so as to form a DC earth which enables direct current to flow therein from the plasma - claim 1.... (emphasis added).

ii. the electrically conductive member has an area in a range of 0.1% to 10% of the inner wall area of the reaction chamber ..., a magnetic field generation means is disposed outside of the reaction chamber ... so as to apply a magnetic field to the plasma, and the electrically conductive member forming the DC earth is disposed at a position crossing a magnetic line of force that is closer to the substrate holder than a magnetic line of force that crosses the inner wall of the reaction chamber... having the dielectric ... thereon - claim 1. (emphasis added).

Thus, with respect to the recited features of claim 1, the Examiner acknowledges that Kadomura et al provides no disclosure or teaching with respect to the following recited features of claim 1:

A) An electrically conductive member disposed within the reaction chamber so as to be exposed to the plasma within the reaction

chamber at a position with respect to the inner wall of the reaction chamber which is covered with the dielectric (emphasis added);

B) The electrically conductive member being electrically coupled to earth one of directly and through the inner wall of the reaction chamber so as to form a DC earth which enables direct current to flow therein from the plasma (emphasis added);

C) The electrically conductive member having an area in a range of 0.1% to 10% of the inner wall area of the reaction chamber (emphasis added); and

D) The electrically conductive member forming the DC earth being disposed at a position crossing a magnetic line of force that is closer to the substrate holder than a magnetic line of force that crosses the inner wall of the reaction chamber having a dielectric thereon (emphasis added).

The Examiner recognizing the aforementioned deficiencies of Kadomura et al, apparently contends that such deficiencies are overcome by the disclosure of Kawasaki et al. However, appellants submit that Kawasaki et al does not disclose the recited features (A-D), as pointed out above, and that the combination of Kadomura et al and Kawasaki et al represents a hindsight reconstruction attempt, in complete disregard of the teachings of the individual references.

Turning to Kawasaki et al, the Examiner at page 8 of the office action indicates that Kawasaki et al teaches a plasma apparatus in Fig. 3, and an electrically conductive member 11 which is electrically coupled to earth. Applicants note that Kawasaki et al describes in column 3, lines 27 - 37 that Fig. 1 shows a microwave plasma treating apparatus using ECR discharge wherein a discharge tube 1 made of silica is disposed at an upper opening of a vacuum treating vessel 4, an electrode 5 having a sample table 5a on which a wafer 6 is a sample is placed is disposed inside the vacuum treating vessel 4, and that a discharge space 7 is formed above the sample table 5a inside the discharge tube 1. Applicants submit that since the discharge tube 1 is made of silica, it is readily apparent that Kawasaki

et al does not disclose that the inner wall of the reaction chamber has a dielectric formed thereon, and assuming arguendo that 4 represents the inner wall of the reaction chamber, there is no disclosure or teaching that the inner wall 4 has a dielectric thereon. While Kawasaki et al discloses a ground electrode 11 disposed around the outer periphery of the electrode 5, there is no disclosure that the ground electrode 11 is disposed at a position with respect to the inner wall of the reaction chamber which is covered with the dielectric, that the electrically conductive member is coupled through the inner wall of the reaction chamber, that the electrically conductive member has an area in a range of 0.1% to 10% of the inner wall area of the reaction chamber, or that the electrically conductive member is disposed at a position crossing a magnetic line of force that is closer to the substrate holder than a magnetic line of force that crosses the inner wall of the reaction chamber having the dielectric thereon.

The Examiner contends however, that such features would apparently flow from the combination of Kawasaki et al and Kadomura et al, and appellants submit that the Examiner cannot ignore such features. Rather, it is apparent that the Examiner has engaged in a hindsight reconstruction attempt, noting that Kawasaki et al issued in 1989 and Kadomura et al was filed in the US in 1998 almost 10 years later, and did not utilize an electrically conductive member in the form of a ground electrode the structural arrangement thereof. Yet, the Examiner contends that it would be obvious to provide Kadomura et al with such structure, even though the structure of Kawasaki et al was available to Kadomura et al and appellants submit that Kadomura et al did not consider it appropriate to utilize such structure of a ground electrode in the invention of Kadomura et al. In any event, the combination fails to provide each of the features (A-D), and at least one of the features (A) - (D),

as indicated above. Thus, applicants submit that claim 1 patentably distinguishes over this proposed combination of references in the sense of 35 USC 103.

It is interesting to note that the Examiner at least recognizes at page 9 of the office action that the area range is not disclosed, with the Examiner apparently suggesting it would be obvious to optimize the exposed/unexposed surface area, irrespective of this position by the Examiner, appellants submit that there is no disclosure or teaching of an electrically conductive member arranged with respect to the sidewall of the reaction chamber having a dielectric provided thereon, wherein the electrically conductive member has an area in a range of 0.1% to 10% of the inner wall area of the reaction chamber having the dielectric thereon, i.e., feature (C) of claim 1. Furthermore, with respect to feature (D), the Examiner apparently takes the position that when the structure recited in the reference is substantially identical to that of the claims, claim properties or functions are presumed to be inherent, citing In re Best, 195 USPQ 430, 433, (CCPA 1977). Applicants note that such decision relates to chemical compositions, whereas the present invention relates to structural features, which, the Examiner recognizes, are not disclosed in the cited art. Appellants submit that a more appropriate decision is that of In re Robertson, 49 USPQ 2d 1949 (Fed. Cir. 1999), wherein the court pointed out that to establish inherency, the extrinsic evidence "must make clear that the missing descriptive matter is necessarily present in the thing described in the reference, and that it would be so recognized by persons of ordinary skill." Moreover, the court pointed out that inherency, however, may not be established by probabilities or possibilities. The mere fact that a certain thing may result from a given set of circumstances is not sufficient. As is apparent, inherency may not be established by possibilities or probabilities, and appellants submit that the recited features of (A)-(D) of claim 1 are

not disclosed or taught by Kadomura et al or Kawasaki et al taken alone or in any combination thereof, such that claim 1 and the dependent claims patentably distinguish over the cited art in the sense of 35 USC 103 and should be considered allowable thereover.

With respect to the dependent claims, it is readily apparent that Kawasaki et al does not disclose a dielectric covering the inner wall of the reaction chamber, irrespective of the disclosure of Kadomura et al such that the features of claim 2 when considered with the features of parent claim 1 patentably distinguish over this proposed combination of references.

With respect to dependent claim 4, such claim recites the feature that the electrically conductive member is located at a position within the reaction chamber where a floating potential of plasma is substantially equal to or greater than a floating potential of the plasma at the inner wall of the reaction chamber covered with the dielectric with respect to the high frequency or the second high frequency. Hereagain, it is apparent that Kadomura et al does not disclose such feature and likewise, there is no disclosure or teaching in Kawasaki et al of this recited feature, which, when considered in conjunction with the parent claims further patentably distinguish over the cited art such that claim 3 should also be considered allowable at this time.

As to dependent claim 5, whether or not Kadomura et al provides a dielectric, there is no disclosure or teaching in Kadomura et al or Kawasaki et al of the relationship of "an impedance per unit area $R=d/(2\pi f\epsilon)$ when high frequency is propagated by capacitive coupling through the dielectric is 100 Ω or smaller". Thus, claim 5 also patentably distinguishes over the cited art in the sense of 35 USC 103.

As to dependent claim 7, since only Kawasaki et al discloses an electrically conductive member in the form of the grounded electrode 11, it is apparent that Kawasaki et al does not disclose “either a base material of the electrically conductive member forming the DC earth or a protective coating disposed on a surface of the electrically conductive member forming the DC earth and coming into contact with the plasma is composed of conductive ceramic SiC, Al or Al compound”, such that claim 7 also patentably distinguishes over the cited art in the sense of 35 USC 103.

Dependent claim 8 again defines a base material of the electrically conductive member and a conductive part of the electrically conductive member which is not disclosed or taught by Kawasaki et al and is also not disclosed or taught by Kadomura et al. Thus, claim 8 recites features which also patentably distinguish over the proposed combination of references in the sense of 35 USC 103 and should be considered allowable thereover.

Dependent claims 10, 11 and 12 recite features identical to claims 6, 7 and 8 with claims 10, 11 and 12 depending from claim 4 and patentably distinguishing over the cited art for the reasons given above. These claims also patentably distinguish over the cited art in the sense of 35 USC 103 and should be considered allowable thereover.

As to dependent claim 13, such claim recites the feature that the electrically conductive member is disposed within the reaction chamber and is electrically coupled to earth by a wire extending through the inner wall of the reaction chamber. Assuming *arguendo* that the grounded electrode 11 of Kawasaki et al represents an electrically conductive member, even though the ground electrode 11 is not arranged in the manner recited in claim 1, it is readily apparent that the ground electrode 11 extends through the bottom of the treatment chamber 4 in Kawasaki et al, and is not

disclosed to be “electrically coupled to earth by a wire extending through the inner wall of the reaction chamber” (emphasis added), noting that the inner wall of the reaction chamber is covered by a dielectric, which is not disclosed by Kawasaki et al. Thus, appellants submit that the features of claim 13 also patentably distinguish over the proposed combination of Kawasaki et al and Kadomura et al, recognizing that that combination also fail to disclose or teach the features of parent claim 1.

With respect to dependent claim 14, which recites the feature that the electrically conductive member is positioned in the reaction chamber so as to enable suppression of the chipping of the surface portion of the inner wall of the reaction chamber, applicants submit that there is no disclosure or teaching in Kadomura et al or Kawasaki et al of such recited feature, and any suggestion of inherency is based upon speculation by the Examiner. Thus, appellants submit that claim 14 recites further features not disclosed or taught by the cited art in the sense of 35 USC 103 and should be considered allowable thereover.

Conclusion

For the foregoing reasons, appellants submit that the final rejection of the claims should be reversed.

Fees


The appeal brief fee is submitted herewith.

A copy of the claims on appeal, i.e., claims 1, 2, 4, 5, 7, 8 and 10 - 14 are found in the attached Claims Appendix, and additional appendices are submitted, as required.

To the extent necessary, applicants petition for an extension of time under 37 CFR 1.136. Please charge any shortage in the fees due in connection with the filing of this paper, including extension of time fees, to the deposit account of Antonelli, Terry, Stout & Kraus, LLP, Deposit Account No. 01-2135 (Case: 648.43518X00), and please credit any excess fees to such deposit account.

Respectfully submitted,

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CLAIMS APPENDIX

1. A plasma processing apparatus for processing a substrate with plasma by applying a high frequency to a reaction chamber so as to generate plasma therein, and applying a second high frequency to a substrate holder on which the substrate is placed so as to control the ion energy to the substrate; wherein

a dielectric that is exposed to the plasma substantially covers a surface portion of an inner wall of the reaction chamber, an electrically conductive member is disposed within the reaction chamber so as to be exposed to the plasma within the reaction chamber at a position with respect to the inner wall of the reaction chamber which is covered with the dielectric, and the electrically conductive member is electrically coupled to earth one of directly and through the inner wall of the reaction chamber so as to form a DC earth which enables direct current to flow therein from the plasma, the electrically conductive member has an area in a range of 0.1% to 10% of the inner wall area of the reaction chamber, a magnetic field generation means is disposed outside of the reaction chamber so as to apply a magnetic field to the plasma, and the electrically conductive member forming the DC earth is disposed at a position crossing a magnetic line of force that is closer to the substrate holder than a magnetic line of force that crosses the inner wall of the reaction chamber having the dielectric thereon.

2. The plasma processing apparatus according to claim 1, wherein

the dielectric covers 90 % or more of a total surface area of the inner wall of the reaction chamber.

4. The plasma processing apparatus according to any one of claims 1 and 2,
wherein

the electrically conductive member forming the DC earth is located at a position within the reaction chamber where a floating potential of plasma is substantially equal to or greater than a floating potential of the plasma at the inner wall of the reaction chamber covered with the dielectric with respect to the high frequency or the second high frequency.

5. The plasma processing apparatus according to any one of claims 1 and 2,
wherein

the dielectric is a protective coating formed of insulating ceramic such as carbide, oxide or nitride, as exemplified by SiC, boron carbide and alumite, and a thickness d of the dielectric coating is determined so that, with respect to the relationship between frequency f of the high frequency applied to the substrate and the dielectric constant ϵ of the dielectric, an impedance per unit area $R = d/(2\pi f\epsilon)$ when high frequency is propagated by capacitive coupling through the dielectric is $100\ \Omega$ or smaller.

7. The plasma processing apparatus according to any one of claims 1 and 2,
wherein

either a base material of the electrically conductive member forming the DC earth or a protective coating disposed on a surface of the electrically conductive member forming the DC earth and coming into contact with the plasma is composed of conductive ceramic, SiC, Al or Al compound.

8. The plasma processing apparatus according to any one of claims 1 and 2, wherein

when a base material of the electrically conductive member forming the DC earth is composed of a non-metallic material such as conductive ceramic, SiC, Al or Al compound, a conductive part having a conductivity σ of $1 \text{ } \Omega\text{cm}$ or less is provided to a surface of the base material by evaporation, spraying or interposing, thereby reducing an earth resistance of the electrically conductive member forming the DC earth.

10. The plasma processing apparatus according to claim 4, wherein

the dielectric is a protective coating formed of insulating ceramic such as carbide, oxide or nitride, as exemplified by SiC, boron carbide and alumite, and a thickness d of the dielectric coating is determined so that, with respect to the relationship between frequency f of the high frequency applied to the substrate and the dielectric constant ϵ of the dielectric, an impedance per unit area $R = d/(2\pi f\epsilon)$ when high frequency is propagated by capacitive coupling through the dielectric is $100 \text{ } \Omega$ or smaller.

11. The plasma processing apparatus according claim 4, wherein

either a base material of the electrically conductive member forming the DC earth or a protective coating disposed on a surface of electrically conductive member forming the DC earth coming into contact with the plasma is composed of conductive ceramic, SiC, Al or Al compound.

12. The plasma processing apparatus according to claim 4, wherein

when a base material of the electrically conductive member forming the DC earth is composed of a non-metallic material such as conductive ceramic, SiC, Al or Al compound, a conductive part having a conductivity σ of 1 Ωcm or less is provided to a surface of the base material by evaporation, spraying or interposing, thereby reducing an earth resistance of the electrically conductive member forming the DC earth.

13. The plasma processing apparatus according to claim 1, wherein the electrically conductive member is disposed within the reaction chamber and is electrically coupled to earth by a wire extending through the inner wall of the reaction chamber.

14. The plasma processing apparatus according to claim 1, wherein the electrically conductive member is positioned in the reaction chamber so as to enable suppression of chipping of the surface portion of the inner wall of the reaction chamber.

EVIDENCE APPENDIX

None

RELATED PROCEEDINGS APPENDIX

None